

Case 2728***Artemia franciscana* Kellogg, 1906 (Crustacea, Branchiopoda): proposed conservation of the specific name**

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Abstract. The purpose of this application is to conserve the specific name of a broadly distributed North American species of brine shrimp, *Artemia franciscana* Kellogg, 1906. The name is threatened by four senior subjective synonyms.

1. Thompson (1834, p. 107) described the new genus and species *Artemis guildingi* on the basis of a single female specimen sent to him by the Reverend L. Guilding. The name *Artemis* is a junior homonym of *Artemis* Kirby & Spence, 1828 (Lepidoptera), and was presumably an unjustified emendation of *Artemia* Leach, 1819, since Thompson refers to 'Artemis salinus [sic], or Brine Shrimp' (cf. BZN 37: 224). Thompson's description consists of the comments 'one female probable of this Genus' and 'biarticulate oviferous sac' along with two drawings, and he gave the locality as the West Indies. The current location of this specimen is unknown. Thompson's proposed name is included in published listings of the species of *Artemia* but has not otherwise been used. Daday (1910, p. 117) placed it in the synonymy of *Artemia salina* (Linnaeus, 1758, p. 634, from 'Anglia'). The inadequacy of Thompson's description makes it impossible to identify his specimen even as to genus. This name is clearly a nomen dubium.

2. Verrill (1869a, p. 248) described *Artemia gracilis* on the basis of specimens collected from large wooden tubs on a railroad bridge across an extensive salt marsh near New Haven, Connecticut. The water, which was much concentrated by evaporation, came from pools in the marsh. A search of the pools from which the water had been collected failed to produce any *Artemia* (Verrill, 1869a, p. 234). Verrill's type material is in the Peabody Museum of Natural History, Yale University, Connecticut (YPM No. 396, 397). Packard (1883, p. 330) discussed four nominal species from the United States (*Artemia gracilis* Verrill, 1869a; *A. monica* Verrill, 1869a; *A. fertilis* Verrill, 1869b; and *A. utahensis* Lockington, 1876) and the European *A. salina* (Linnaeus, 1758), and enumerated what he considered species-specific morphological differences between the American species and the European *Artemia salina*. Regarding Verrill's species he stated '... I do not regard the difference he [Verrill] points out as more than individual', and placed Verrill's three species (together with *utahensis* with no explanation — one can only guess that he was influenced by the fact that both *fertilis* and *utahensis* were

names for *Artemia* from the same lake; cf. para. 7) under the first cited available name, *gracilis*. Daday (1910, p. 117), influenced by work demonstrating that the morphology of Eurasian *Artemia* undergoes what at that time were considered taxonomically important changes when cultured at different salinities, synonymized the four nominal species from the United States under *Artemia salina*. Jensen (1918) and Relyea (1937), apparently unaware of Daday's synonymy since they did not cite his work, followed Packard in referring *Artemia* from Great Salt Lake, Utah, to *A. gracilis*. Bond (1933) found no relationship between salinity and morphology for *Artemia* from Monterey Bay, California, and thus chose not to follow Daday's synonymy.

3. Kellogg (1906, p. 596), stating there were three species of *Artemia* recognized in America (*gracilis*, *fertilis* and *monica*), described a new species, *Artemia franciscana*, from a salt works at Redwood City on the west shore of San Francisco Bay, California. Noting the closeness of the habitats, Bond (1933) tentatively referred the Monterey Bay *Artemia* to *A. franciscana* but did not refer to *gracilis* at all. The Monterey Bay population had previously been referred to *A. franciscana* by Martin & Wilber (1921) and to *A. salina* by Heath (1924). Keunen (1939) demonstrated reproductive isolation between *Artemia* from salt works near Cagliari, Sardinia, Italy, and at Monterey Bay. On the basis of these findings and others he reviewed, Keunen concluded that the American *Artemia* was specifically distinct from the European *Artemia*. He reviewed the nomenclatural history of the genus *Artemia* and on the basis of priority used *A. gracilis* Verrill, 1869 for the American species. He considered the clearly separate European species to be *Artemia salina* (Linnaeus, 1758). However, most other authors were unaware of or ignored Keunen's work and in general followed Daday (1910) in using the name *A. salina* for all populations of the genus *Artemia*. Undoubtedly the widely used keys of Pennak (1952, 1978) and Dexter (1959) were largely responsible for the continued use in North America of the binomen *Artemia salina*. Belk (1975), unaware of Keunen's work, followed the pattern set by Pennak and Dexter in publishing a key to the Anostraca of North America.

4. During the 1960's and 70's, *Artemia* came to be recognized as a complex of sibling species. Bowen et al. (1978), in a paper that cites the key works in the development of the concept of *Artemia* as such a complex, classified two identifiable North American sibling species as *A. monica* Verrill, 1869 and *A. franciscana* Kellogg, 1906. The Great Salt Lake population, and also populations in the West Indies (cf. para. 1), were included in *franciscana*. *Artemia monica* is a clearly defined taxon endemic to only one unique salt lake and represents no nomenclatural problem. Since the publication of Bowen et al. (1978), *A. franciscana* has been generally and widely accepted as the name of the broadly distributed North American species of *Artemia* as illustrated in these ten papers, many of which are major reviews: Abreu-Grobois (1987), Bowen & Sterling (1978), Bowen et al. (1980), Browne & Bowen (in press), Eng et al. (1990), Hedgecock et al. (1982), Lenz (1987), Mura et al. (1989), Spotte & Anderson (1988) and Vanhaecke et al. (1987). A list of 17 other references demonstrating this general acceptance of *franciscana* is held in the office of the Secretariat. Correspondence in the *Artemia Newsletter* also evidences acceptance (Abreu-Grobois, 1989; Yaneng, 1989). *Artemia* workers find, as did Packard (1883, p. 330), that there are no morphological characters useful in separating Verrill's eastern United States *gracilis* from the western sibling species. The only examples of *gracilis* available for study are museum specimens. Natural habitats of *gracilis* are unknown. The Connecticut wooden tub type locality

ceased to exist long ago, and there are no reports during this century of *Artemia* from states east of the Mississippi River. In the only early records, Verrill (1869b, p. 430) notes an observation of *Artemia* by Agassiz in salines on Cape Cod and another by G.H. Perkins in tubs on a railroad bridge near Boston, Massachusetts. Without live material, *gracilis* cannot be studied using the methods that lead to recognition of *franciscana* and *monica*, nor can it be compared with them. Thus the relationship of *gracilis* to the other sibling species remains unknown, and is at this time unresolvable. This lack of access to living *gracilis* left Bowen et al. (1978) with only one name that could be clearly and unequivocally assigned to the populations they studied — *Artemia franciscana* Kellogg, 1906.

5. When Bowen et al. (1978) chose to apply the binomen *A. franciscana* Kellogg, 1906 not only to Californian material but also to the Great Salt Lake population of *Artemia*, the then current 1964 edition of the Code indicated in Article 23b that the name *fertilis* Verrill, 1869, unused since 1883, could be rejected as a nomen oblitum; the authors were unaware that this Article had been revoked from January 1973.

6. Amat Domenech (1980) demonstrated morphological differences between *Artemia* from Europe and California. He identified the European species as *Artemia salina* (Linnaeus, 1758). He referred the American species to *A. gracilis* Verrill, 1869. However, his use of *gracilis* has not been followed by subsequent authors for reasons discussed in para. 4.

7. Packard (1883, p. 330) included in his synonymy under *A. gracilis* the name *A. utahensis* Lockington, 1876. The Lockington reference Packard cites is a report of a paper that Lockington read before the San Francisco Microscopical Society. The report (p. 137) was most likely written by Henry Lawson, editor of the journal the report appears in. It is probable that Lockington, after giving his paper, learned that Verrill (1869b) had already named the Great Salt Lake *Artemia* as *fertilis*, and so never published in full the description discussed at the San Francisco meeting.

8. Although we are advocates of the Principle of Priority, it is our opinion that stability will best be served in this instance by suppression of the names *guldingi*, *fertilis* and *utahensis* which have not been used as senior synonyms since their original publication. The first of these, *guldingi*, is based on an inadequate description of a single female, now lost. The other two, *fertilis* and *utahensis*, were both described from the Great Salt Lake population which has been extensively studied and shown to be conspecific with *A. franciscana* on the basis of cross-fertility and similarity of isozyme patterns (Bowen, 1964; Clark & Bowen, 1967; Bowen & Sterling, 1978). Both names have remained unused since Packard (1883, p. 330) listed them as junior synonyms of *A. gracilis*. No author has even considered them enough to list them formally as synonyms of *franciscana*. There is currently a rapidly growing literature dealing with *A. franciscana* (cf. para. 4). The relationship of *gracilis* to *franciscana* is doubtful, as explained in para. 4. If at some future time this situation should change and the two names should be considered synonyms, assigning priority to *gracilis* would cause serious confusion because of the very extensive use of *A. franciscana* in a wide range of studies (see para. 4).

9. The International Commission on Zoological Nomenclature is accordingly asked:

(1) to use its plenary powers:

(a) to suppress the following names for the purposes of the Principle of Priority but not for those of the Principle of Homonymy:

- (i) *guldingi* Thompson, 1834, as published in the binomen *Artemis guldingi*;
 - (ii) *fertilis* Verrill, 1869, as published in the binomen *Artemia fertilis*;
 - (iii) *utahensis* Lockington, 1876, as published in the binomen *Artemia utahensis*;
- (b) to give precedence to the specific name *franciscana* Kellogg, 1906, as published in the binomen *Artemia franciscana*, over *gracilis* Verrill, 1869, as published in the binomen *Artemia gracilis*, whenever the two names are considered to be synonyms;
- (2) to place the following names on the Official List of Specific Names in Zoology:
- (a) *franciscana* Kellogg, 1906, as published in the binomen *Artemia franciscana*, with the endorsement that it is to be given precedence over *gracilis* Verrill, 1869, as published in the binomen *Artemia gracilis*, whenever the two names are considered to be synonyms;
 - (b) *gracilis* Verrill, 1869, as published in the binomen *Artemia gracilis*, with the endorsement that it is not to be given priority over *franciscana* Kellogg, 1906 as published in the binomen *Artemia franciscana*, whenever the two names are considered to be synonyms;
- (3) to place the following names on the Official Index of Rejected and Invalid Specific Names in Zoology:
- (a) *guldingi* Thompson, 1834, as published in the binomen *Artemis guldingi* and as suppressed in (1)(a)(i) above;
 - (b) *fertilis* Verrill, 1869, as published in the binomen *Artemia fertilis* and as suppressed in (1)(a)(ii) above;
 - (c) *utahensis* Lockington, 1876, as published in the binomen *Artemia utahensis* and as suppressed in (1)(a)(iii) above;

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References

- Abreu-Grobois, F.A. 1987. A review of the genetics of *Artemia*. Pp. 61–99 In Sorgeloos, P., Bengtson, D.A., Declair, W. & Jaspers, E. (Eds.), *Artemia: Research and its applications*, vol. 1. 359 pp. Universa Press, Belgium.
- Abreu-Grobois, F.A. 1989. Observations and questions with regard to *Artemia* taxonomy. *Artemia Newsletter*, 12(April): 5–8.
- Amat Domenech, F. 1980. Differentiation in *Artemia* strains from Spain. Pp. 19–39 in Persoone, G., Sorgeloos, P., Roels, O. & Jaspers, E. (Eds.), *The brine shrimp Artemia*, vol. 1. Morphology, genetics, radiobiology, toxicology. 318 pp. Universa Press, Belgium.
- Baird, W. 1852. Monograph of the family Branchiopodidae, a family of crustaceans belonging to the division Entomostraca, with a description of a new genus and species of the family, and two new species belonging to the family Limnadidae. *Proceedings of the Zoological Society of London*, 1852: 18–37.
- Belk, D. 1975. Key to the Anostraca (Fairy Shrimps) of North America. *The Southwestern Naturalist*, 20: 91–103.
- Bond, R.M. 1933. Observations on *Artemia 'franciscana'* Kellogg, especially on the relation of environment to morphology. *Internationale Revue der gesamten Hydrobiologie*, 28: 117–125.
- Bowen, S.T. 1964. The genetics of *Artemia salina*. Part 4. Hybridization of wild populations with mutant stocks. *Biological Bulletin*, 126: 333–344.

- Bowen, S.T., Durkin, J.P., Sterling, G. & Clark, L.S. 1978. *Artemia* hemoglobins: Genetic variation in parthenogenetic and zygotenetic populations. *Biological Bulletin*, **155**: 273–287.
- Bowen, S.T. & Sterling, G. 1978. Esterase and malate dehydrogenase isoenzyme polymorphisms in 15 *Artemia* populations. *Comparative Biochemistry and Physiology*, **61B**: 593–595.
- Bowen, S.T., Davis, M.L., Fenster, S.R. & Lindwall, G.A. 1980. Sibling species of *Artemia*. Pp. 155–167 In Persoone, G., Sorgeloos, P., Roels, O. & Jaspers, E. (Eds.), *The brine shrimp Artemia*, vol. 1. Morphology, genetics, radiobiology, toxicology. 318 pp. Universa Press, Belgium.
- Browne, R.A. & Bowen, S.T. In press. Taxonomy and population genetics of *Artemia*. In *Biology of Artemia*. CRC Press.
- Clark, L. & Bowen, S.T. 1976. The genetics of *Artemia salina*. Part 7 (reproductive isolation). *Journal of Heredity*, **67**: 385–388.
- Daday, E. 1910. Monographie systématique des Phyllopoies Anostracés. *Annales des Sciences Naturelles, Zoologie*, (9)**11**: 111–489.
- Dexter, R.W. 1959. Anostraca. Pp. 558–571 In Edmondson, W.T. (Ed.) *Fresh-water biology*, Ed. 2. 1248 pp. Wiley & Sons, New York.
- Eng, L.L., Belk, D. & Eriksen, C.H. 1990. California Anostraca: distribution, habitat, and status. *Journal of Crustacean Biology*, **10**(2): 247–277.
- Heath, H. 1924. The external development of certain phyllopoies. *Journal of Morphology*, **38**: 453–463.
- Hedgecock, D., Tracey, M.L. & Nelson, K. 1982. Genetics. Pp. 283–403 In Bliss, D.E. (Ed.-in-chief). *The Biology of Crustacea*, vol. 2, Abele, L.G. (Ed.), Embryology, morphology and genetics. 440 pp. Academic Press, New York.
- Jensen, A.C. 1918. Some observations on *Artemia gracilis*, the brine shrimp of Great Salt Lake. *Biological Bulletin*, **34**: 18–33.
- Kellogg, V.L. 1906. A new *Artemia* and its life conditions. *Science*, (n.s.)**24**: 594–596.
- Kuonen, D.J. 1939. Systematical and physiological notes on the brine shrimp *Artemia*. *Archives Néerlandaises de Zoologie*, **3**: 365–449.
- Lenz, P.H. 1987. Ecological studies on *Artemia*: a review. Pp. 5–17 In Sorgeloos, P., Bengtson, D.A., Decler, W. & Jaspers, E. (Eds.), *Artemia: Research and its applications*, vol. 3. 535 pp. Universa Press, Belgium.
- Lockington, W. 1876. [A new Phyllopoious Crustacean], in [Lawson, H.] (Ed.), *The Monthly Microscopical Journal: Transactions of the Royal Microscopical Society, and Record of Histological Research at Home and Abroad*, **15**: 137.
- Martin, E.G. & Wilbur, B.C. 1921. Salt antagonism in *Artemia*. *American Journal of Physiology*, **55**: 290–291.
- Mura, G., Del Caldo, L. & Fanfani, A. 1989. Sibling species of *Artemia*: a light and electron microscopic survey of the morphology of the frontal knobs. Part 1. *Journal of Crustacean Biology*, **9**: 414–419.
- Packard, A.S. Jr. 1883. A monograph of the phyllopoies Crustacea of North America with remarks on the order Phyllocarida. *Twelfth Annual Report of the U.S. Geological and Geographical Survey of the Territories: A Report of Progress of the Exploration in Wyoming and Idaho for the Year 1878*. (F.V. Hayden, U.S. geologist). Part 1, section 2, pp. 295–592, 39 pls.
- Pennak, R.W. 1952. *Fresh-water invertebrates of the United States*. Wiley & Sons, New York.
- Pennak, R.W. 1978. *Fresh-water invertebrates of the United States*. Ed. 2. 803 pp. Wiley & Sons, New York.
- Relyea, G.M. 1937. The brine shrimp of Great Salt Lake. *The American Naturalist*, **71**: 612–616.
- Spotte, S. & Anderson, G. 1988. Chemical decapsulation of resting cysts of the anostracans *Artemia franciscana* and *Streptocephalus seali* as revealed by scanning electron microscopy. *Journal of Crustacean Biology*, **8**: 221–231.
- Thompson, J.V. 1834. Development of *Artemis salinus*, or Brine Shrimp; demonstrative of its relationship to *Branchipus* and other Crustaceous Phyllopoies, and to those enigmatic Fossils, the apparently eyeless Trilobites... with a new species of *Artemis* and of *Apus*. *Zoological Researches and Illustrations 1828–1834*, Vol. 1, part 1, memoir 6. Pp. 103–112, 6 pls.

- Vanhaecke, P., Tackaert, W. & Sorgeloos, P.** 1987. The biogeography of *Artemia*: an updated review. In Sorgeloos, P., Bengtson, D.A., Decleir, W. & Jaspers, E. (Eds.), *Artemia: Research and its applications*, vol. 1. 359 pp. Universa Press, Belgium.
- Verrill, A.E.** 1869a. Descriptions of some new American Phyllopod Crustacea. *American Journal of Science and Arts*, (2)**48**: 244–254.
- Verrill, A.E.** 1869b. New localities of *Artemia*. *American Journal of Science and Arts*, (2)**48**: 430.
- Yaneng, C.** 1989. New *Artemia* sibling species from PR China. *Artemia Newsletter*, **11**(January): 40–41.